

## **DESCRIPTION**

### **TITLE OF INVENTION: VISUAL TRAINING METHOD AND SYSTEM BASED ON DICHOPTIC VIEWING**

#### **TECHNICAL FIELD**

**[0001]** The present disclosure relates to the technical field of visual training, and in particular, to a visual training method and system based on dichoptic viewing.

#### **BACKGROUND**

**[0002]** A main principle of visual training is to activate a visual system by providing visual stimuli, to promote its neuroplastic adaptation and enhance a visual information processing capability.

**[0003]** Dichoptic viewing is a visual technology that allows the left and right eyes to observe different image information, thereby enabling the perception of a three-dimensional (3D) effect. Each eye can obtain a different perspective, which is then fused into a single 3D image.

**[0004]** An existing visual training method mainly involves covering an eye with good visual acuity, namely, a dominant eye, and performing a visual training task on an eye with reduced visual acuity, namely, an amblyopic eye (an eye with suboptimal visual acuity), to enhance visual stimulation and use of the amblyopic eye, activate visual neurons and visual pathways, promote plasticity adjustment, and improve a visual information processing capability. However, covering one eye has great impact on visual experience. This halves a visual field, hinders spatial perception to some extent, and affects visual training. In addition, the monocular visual input results in limited adaptability for the user to the visual environment and fails to train the coordination and balance of binocular visual functions, thereby reducing the visual training effect.

**[0005]** In addition, an existing visual training device usually presents dynamic images based on a fixed change rule, and cannot dynamically adjust the images based on an actual visual condition of a user. Consequently, an accurate visual training method cannot be formulated based on the actual condition of the user, to reduce a visual training effect.

#### **SUMMARY**

**[0006]** To resolve the foregoing problems, the present disclosure provides a visual training method and system based on dichoptic viewing, to improve a visual training effect.

**[0007]** To achieve the foregoing objective, according to a first aspect, the present disclosure provides a visual training method based on dichoptic viewing, including:

**[0008]** determining a dominant eye and an amblyopic eye of a user based on obtained binocular visual-acuity information of the user and respectively creating image display channels for the dominant eye and the amblyopic eye of the user through a preset dichoptic viewing technology, where the image display channels include a dominant-eye display channel and an amblyopic-eye display channel;

**[0009]** simultaneously displaying a plurality of preset first training images on the dominant-eye display channel and the amblyopic-eye display channel; and when displaying each of the first training images on the dominant-eye display channel, obtaining, through a preset eye tracking technology, gaze point coordinates of the dominant eye gazing at the first training image;

**[0010]** performing, through a preset Gaussian blur function based on the gaze point coordinates and the binocular visual-acuity information, a Gaussian blur on each of the first training images displayed on the dominant-eye display channel, to obtain a plurality of second training images after the Gaussian blur;

**[0011]** displaying the second training images on the dominant-eye display channel while displaying the first training images on the amblyopic-eye display channel to enable visual training of the user, and acquiring visual training duration of the user; and

**[0012]** when the visual training duration reaches a preset time threshold, stopping displaying the first training images to complete the visual training of the user.

**[0013]** The visual training method based on dichoptic viewing provided by the present disclosure includes: The binocular visual-acuity information of the user is obtained to determine the amblyopic eye and the dominant eye of the user for accurate training based on an actual binocular visual-acuity condition of the user. Then, the image display channels are respectively created for the dominant eye and the amblyopic eye of the user through the preset dichoptic viewing technology, to enable simultaneous visual training of left and right eyes of the user. In this way, both eyes simultaneously work, to effectively reduce inhibition between both eyes and improve a visual training effect. After the image display channels are created, the preset first training image is played on the dominant-eye display channel, and the gaze point coordinates of the dominant eye gazing at the first image are obtained through the preset eye tracking technology. The Gaussian-blurred area on the dominant-eye display channel is determined through the preset Gaussian blur function based on the gaze point coordinates and the binocular visual-acuity information. When the preset training image is simultaneously

played on the dominant-eye display channel and the amblyopic-eye display channel, the training image on the dominant-eye display channel is blurred based on the blurred area and the Gaussian blur function, to effectively reduce inhibition of the dominant eye on the amblyopic eye. In this way, the amblyopic eye of the user receives a normal and sharp image during visual training, to increase a frequency of using the amblyopic eye, train coordination and balance of binocular visual functions, and improve the visual training effect.

**[0014]** In a preferred example, the determining a dominant eye and an amblyopic eye of a user based on obtained binocular visual-acuity information of the user and respectively creating image display channels for the dominant eye and the amblyopic eye of the user through a preset dichoptic viewing technology includes:

**[0015]** obtaining left-eye corrected visual acuity and right-eye corrected visual acuity of the user, and determining the dominant eye and the amblyopic eye of the user by comparing the left-eye corrected visual acuity and the right-eye corrected visual acuity, where the binocular visual-acuity information includes the left-eye corrected visual acuity and the right-eye corrected visual acuity; and

**[0016]** creating a first image display channel and a second image display channel based on the preset dichoptic viewing technology such that the amblyopic eye and the dominant eye of the user respectively gaze at, through the first image display channel and the second image display channel, a training image used for visual training.

**[0017]** In the present disclosure, the binocular visual-acuity information of the user is first obtained to determine the dominant eye and the amblyopic eye of the user such that a dedicated visual training method is subsequently formulated based on a visual condition of the user to improve visual training accuracy. Then, the first image display channel and the second image display channel are constructed through the preset dichoptic viewing technology such that both eyes of the user view the training image to ensure simultaneous training of both eyes and improve coordination and balance of binocular visual functions.

**[0018]** In a preferred example, the simultaneously displaying a plurality of preset first training images on the dominant-eye display channel and the amblyopic-eye display channel includes:

**[0019]** reading a preset training video file, and performing image parsing on the training video file to obtain the plurality of first training images corresponding to the training video file; and

**[0020]** copying the plurality of first training images to the dominant-eye display channel and the amblyopic-eye display channel such that the plurality of first training images are displayed on the dominant-eye display channel and the amblyopic-eye display channel.

**[0021]** In the present disclosure, image parsing is performed on the training video file, and a

plurality of parsed images are copied to the dominant-eye display channel and the amblyopic-eye display channel. This ensures that the user observes uniform images during visual training, to ensure coordinated training of both eyes and thus improve the visual training effect.

**[0022]** In a preferred example, the obtaining, through a preset eye tracking technology, gaze point coordinates of the dominant eye gazing at the first training image includes:

**[0023]** capturing, based on a preset eye-tracking sensor, an eye-tracking line of sight of the dominant eye of the user gazing at the first training image; and

**[0024]** calculating coordinates of an intersection point of the eye-tracking line of sight and the first training image through a coordinate calculation function preset in the eye-tracking sensor, and obtaining the gaze point coordinates at which the eye-tracking line of sight of the dominant eye of the user falls on the first training image.

**[0025]** In the present disclosure, when the first training image is played on the dominant-eye display channel, the eye-tracking line of sight of the dominant eye of the user gazing at the first training image is captured in real time through the preset eye tracking technology, to obtain the gaze point coordinates of the dominant eye on the first training image. In this way, a Gaussian-blurred area is subsequently determined based on the gaze point coordinates, and the training image on the dominant-eye display channel is blurred, to increase a frequency at which the user uses the amblyopic eye and implement visual training.

**[0026]** In a preferred example, the performing, through a preset Gaussian blur function based on the gaze point coordinates and the binocular visual-acuity information, a Gaussian blur on each of the first training images displayed on the dominant-eye display channel includes:

**[0027]** determining a size of a convolution kernel, standard deviations in two-dimensional (2D) directions, and a blurred area radius centered on a gaze point in the Gaussian blur function, based on corrected visual acuity of the amblyopic eye;

**[0028]** obtaining, with the gaze point coordinates as a center based on the blurred area radius centered on the gaze point, a blurred area of each of the first training images displayed on the dominant-eye display channel; and

**[0029]** performing the Gaussian blur on the blurred area of each of the first training images through the Gaussian blur function based on the size of the convolution kernel and the standard deviations in the 2D directions to obtain the second training images after the Gaussian blur.

**[0030]** In the present disclosure, the corrected visual acuity of the amblyopic eye is utilized to determine each parameter value in the Gaussian blur function, to ensure that the Gaussian blur is performed on the image on the dominant-eye display channel based on an amblyopia degree of the amblyopic eye. Different blur degrees are determined for different amblyopia degrees,

and different visual training degrees are specified for visual conditions of different users, to better meet visual training requirements of different users. The corrected visual acuity of the amblyopic eye is also utilized to blur the image on the dominant-eye display channel. In this way, the dominant eye receives an image with a blurred area, whereas the amblyopic eye receives a normal and sharp image. This effectively reduces inhibition of the dominant eye on the amblyopic eye, to increase the frequency at which the user uses the amblyopic eye and thus improve the visual training effect of the user.

**[0031]** According to a second aspect, the present disclosure provides a visual training system based on dichoptic viewing, including: an image display module, an eye tracking module, an image processing module, a visual training module, and a training ending module.

**[0032]** The image display module is configured to determine a dominant eye and an amblyopic eye of a user based on obtained binocular visual-acuity information of the user and respectively create image display channels for the dominant eye and the amblyopic eye of the user through a preset dichoptic viewing technology. The image display channels include a dominant-eye display channel and an amblyopic-eye display channel.

**[0033]** The eye tracking module is configured to simultaneously display a plurality of preset first training images on the dominant-eye display channel and the amblyopic-eye display channel; and when displaying each of the first training images on the dominant-eye display channel, obtain, through a preset eye tracking technology, gaze point coordinates of the dominant eye gazing at the first training image.

**[0034]** The image processing module is configured to perform, through a preset Gaussian blur function based on the gaze point coordinates and the binocular visual-acuity information, a Gaussian blur on each of the first training images displayed on the dominant-eye display channel, to obtain a plurality of second training images after the Gaussian blur.

**[0035]** The visual training module is configured to display the second training images on the dominant-eye display channel while displaying the first training images on the amblyopic-eye display channel to enable visual training of the user, and acquire visual training duration of the user.

**[0036]** The training ending module is configured to: when the visual training duration reaches a preset time threshold, stop displaying the first training images to complete the visual training of the user.

**[0037]** The visual training system based on dichoptic viewing provided by the present disclosure includes: The binocular visual-acuity information of the user is obtained to determine the amblyopic eye and the dominant eye of the user for accurate training based on

an actual binocular visual-acuity condition of the user. Then, the image display channels are respectively created for the dominant eye and the amblyopic eye of the user through the preset dichoptic viewing technology, to enable simultaneous visual training of left and right eyes of the user. In this way, both eyes simultaneously work, to effectively reduce inhibition between both eyes and improve a visual training effect. After the image display channels are created, the preset first training image is played on the dominant-eye display channel, and the gaze point coordinates of the dominant eye gazing at the first image are obtained through the preset eye tracking technology. The Gaussian-blurred area on the dominant-eye display channel is determined through the preset Gaussian blur function based on the gaze point coordinates and the binocular visual-acuity information. When the preset training image is simultaneously played on the dominant-eye display channel and the amblyopic-eye display channel, the training image on the dominant-eye display channel is blurred based on the blurred area and the Gaussian blur function, to effectively reduce inhibition of the dominant eye on the amblyopic eye. In this way, the amblyopic eye of the user receives a normal and sharp image during visual training, to increase a frequency of using the amblyopic eye, train coordination and balance of binocular visual functions, and improve the visual training effect.

**[0038]** In a preferred example, the image display module includes an information obtaining unit and a channel display unit.

**[0039]** The information obtaining unit is configured to obtain left-eye corrected visual acuity and right-eye corrected visual acuity of the user, and determine the dominant eye and the amblyopic eye of the user by comparing the left-eye corrected visual acuity and the right-eye corrected visual acuity. The binocular visual-acuity information includes the left-eye corrected visual acuity and the right-eye corrected visual acuity.

**[0040]** The channel display unit is configured to create a first image display channel and a second image display channel based on the preset dichoptic viewing technology, such that the amblyopic eye and the dominant eye of the user respectively gaze at, through the first image display channel and the second image display channel, a training image used for visual training.

**[0041]** In the present disclosure, the binocular visual-acuity information of the user is first obtained to determine the dominant eye and the amblyopic eye of the user, such that a dedicated visual training method is subsequently formulated based on a visual condition of the user to improve visual training accuracy. Then, the first image display channel and the second image display channel are constructed through the preset dichoptic viewing technology, such that both eyes of the user view the training image to ensure simultaneous training of both eyes and improve coordination and balance of binocular visual functions.

**[0042]** In a preferred example, the eye tracking module includes an image display unit and an eye tracking unit.

**[0043]** The image display unit is configured to read a preset training video file, and perform image parsing on the training video file to obtain the plurality of first training images corresponding to the training video file; and copy the plurality of first training images to the dominant-eye display channel and the amblyopic-eye display channel such that the plurality of first training images are displayed on the dominant-eye display channel and the amblyopic-eye display channel.

**[0044]** The eye tracking unit is configured to capture, based on a preset eye-tracking sensor, an eye-tracking line of sight of the dominant eye of the user gazing at the first training image; and calculate coordinates of an intersection point of the eye-tracking line of sight and the first training image through a coordinate calculation function preset in the eye-tracking sensor, and obtain the gaze point coordinates at which the eye-tracking line of sight of the dominant eye of the user falls on the first training image.

**[0045]** In the present disclosure, image parsing is performed on the training video file, and a plurality of parsed images are copied to the dominant-eye display channel and the amblyopic-eye display channel. This ensures that the user observes uniform images during visual training, thereby coordinating the training of both eyes and improving the visual training effect. Then, when the first training image is played on the dominant-eye display channel, the eye-tracking line of sight of the dominant eye of the user gazing at the first training image is captured in real time through the preset eye tracking technology, to obtain the gaze point coordinates of the dominant eye on the first training image. In this way, a Gaussian-blurred area is subsequently determined based on the gaze point coordinates, and the training image on the dominant-eye display channel is blurred, to increase a frequency at which the user uses the amblyopic eye and implement visual training.

**[0046]** In a preferred example, the image processing module includes a parameter determining unit, an area calculation unit, and a Gaussian blur unit.

**[0047]** The parameter determining unit is configured to determine a size of a convolution kernel, standard deviations in 2D directions, and a blurred area radius centered on a gaze point in the Gaussian blur function based on corrected visual acuity of the amblyopic eye.

**[0048]** The area calculation unit is configured to obtain, with the gaze point coordinates as a center based on the blurred area radius centered on the gaze point, a blurred area of each of the first training images displayed on the dominant-eye display channel.

**[0049]** The Gaussian blur unit is configured to perform the Gaussian blur on the blurred area

of each of the first training images through the Gaussian blur function based on the size of the convolution kernel and the standard deviations in the 2D directions to obtain the second training images after the Gaussian blur.

**[0050]** In the present disclosure, the corrected visual acuity of the amblyopic eye is utilized to determine each parameter value in the Gaussian blur function, to ensure that the Gaussian blur is performed on the image on the dominant-eye display channel based on an amblyopia degree of the amblyopic eye. Different blur degrees are determined for different amblyopia degrees, and different visual training degrees are specified for visual conditions of different users, to better meet visual training requirements of different users. The corrected visual acuity of the amblyopic eye is also utilized to blur the image on the dominant-eye display channel. In this way, the dominant eye receives an image with a blurred area, whereas the amblyopic eye receives a normal and sharp image. This effectively reduces inhibition of the dominant eye on the amblyopic eye, to increase the frequency at which the user uses the amblyopic eye and thus improve the visual training effect of the user.

**[0051]** According to a third aspect, the present disclosure provides a computer-readable storage medium, storing a computer program. The program, when executed by a processor, implements the visual training method based on dichoptic viewing according to the first aspect.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

**[0052]** FIG. 1 is a schematic flowchart of a visual training method based on dichoptic viewing according to an embodiment of the present disclosure;

**[0053]** FIG. 2 is a schematic structural diagram of a visual training system based on dichoptic viewing according to an embodiment of the present disclosure; and

**[0054]** FIG. 3 is a schematic flowchart of a visual training method based on dichoptic viewing according to another embodiment of the present disclosure.

### **DETAILED DESCRIPTION**

**[0055]** The technical solutions in the embodiments of the present disclosure are clearly and completely described below with reference to the accompanying drawings in the embodiments of the present disclosure. Apparently, the described embodiments are merely some rather than all of the embodiments of the present disclosure. All other embodiments obtained by those of ordinary skill in the art based on the embodiments of the present disclosure without creative efforts should fall within the protection scope of the present disclosure.

**[0056]** Embodiment 1

**[0057]** This embodiment of the present disclosure provides a visual training method based on dichoptic viewing. For a specific implementation process of the method, refer to FIG. 1. The method mainly includes steps 101 to 105. The steps mainly include:

**[0058]** Step 101: Determine a dominant eye and an amblyopic eye of a user based on obtained binocular visual-acuity information of the user and respectively create image display channels for the dominant eye and the amblyopic eye of the user through a preset dichoptic viewing technology. The image display channels include a dominant-eye display channel and an amblyopic-eye display channel.

**[0059]** In this embodiment, this step mainly includes: Obtain left-eye corrected visual acuity and right-eye corrected visual acuity of the user, and determine the dominant eye and the amblyopic eye of the user by comparing the left-eye corrected visual acuity and the right-eye corrected visual acuity, where the binocular visual-acuity information includes the left-eye corrected visual acuity and the right-eye corrected visual acuity; and create a first image display channel and a second image display channel based on the preset dichoptic viewing technology such that the amblyopic eye and the dominant eye of the user respectively gaze at, through the first image display channel and the second image display channel, a training image used for visual training.

**[0060]** In this embodiment, the binocular visual-acuity information of the user is first obtained to determine the dominant eye and the amblyopic eye of the user such that a dedicated visual training method is subsequently formulated based on a visual condition of the user to improve visual training accuracy. Then, the first image display channel and the second image display channel are constructed through the preset dichoptic viewing technology such that both eyes of the user view the training image to ensure simultaneous training of both eyes and improve coordination and balance of binocular visual functions.

**[0061]** Step 102: Simultaneously display a plurality of preset first training images on the dominant-eye display channel and the amblyopic-eye display channel; and when displaying each of the first training images on the dominant-eye display channel, obtain, through a preset eye tracking technology, gaze point coordinates of the dominant eye gazing at the first training image.

**[0062]** In this embodiment, this step mainly includes: Read a preset training video file, and perform image parsing on the training video file to obtain the plurality of first training images corresponding to the training video file; copy the plurality of first training images to the dominant-eye display channel and the amblyopic-eye display channel such that the plurality of first training images are displayed on the dominant-eye display channel and the amblyopic-eye

display channel; capture, based on a preset eye-tracking sensor, an eye-tracking line of sight of the dominant eye of the user gazing at the first training image; and calculate coordinates of an intersection point of the eye-tracking line of sight and the first training image through a coordinate calculation function preset in the eye-tracking sensor, and obtain the gaze point coordinates at which the eye-tracking line of sight of the dominant eye of the user falls on the first training image.

**[0063]** In this embodiment, image parsing is performed on the training video file, and a plurality of parsed images are copied to the dominant-eye display channel and the amblyopic-eye display channel. This ensures that the user observes uniform images during visual training, thereby coordinating the training of both eyes and improving a visual training effect. Then, when the first training image is played on the dominant-eye display channel, the eye-tracking line of sight of the dominant eye of the user gazing at the first training image is captured in real time through the preset eye tracking technology, to obtain the gaze point coordinates of the dominant eye on the first training image. In this way, a Gaussian-blurred area is subsequently determined based on the gaze point coordinates, and the training image on the dominant-eye display channel is blurred, to increase a frequency at which the user uses the amblyopic eye and implement visual training.

**[0064]** Step 103: Perform, through a preset Gaussian blur function based on the gaze point coordinates and the binocular visual-acuity information, a Gaussian blur on each of the first training images displayed on the dominant-eye display channel, to obtain a plurality of second training images after the Gaussian blur.

**[0065]** In this embodiment, this step mainly includes: Determine a size of a convolution kernel, standard deviations in 2D directions, and a blurred area radius centered on a gaze point for the Gaussian blur function based on corrected visual acuity of the amblyopic eye; obtain, with the gaze point coordinates as a center based on the blurred area radius centered on the gaze point, a blurred area of each of the first training images displayed on the dominant-eye display channel; and perform the Gaussian blur on the blurred area of each of the first training images through the Gaussian blur function based on the size of the convolution kernel and the standard deviations in the 2D directions to obtain the second training images after the Gaussian blur.

**[0066]** In this embodiment, the corrected visual acuity of the amblyopic eye is utilized to determine each parameter value in the Gaussian blur function, to ensure that the Gaussian blur is performed on the image on the dominant-eye display channel based on an amblyopia degree of the amblyopic eye. Different blur degrees are determined for different amblyopia degrees, and different visual training degrees are specified for visual conditions of different users, to

better meet visual training requirements of different users. The corrected visual acuity of the amblyopic eye is also utilized to blur the image on the dominant-eye display channel. In this way, the dominant eye receives an image with a blurred area, whereas the amblyopic eye receives a normal and sharp image. This effectively reduces the inhibition of the dominant eye on the amblyopic eye, increasing the frequency at which the user uses the amblyopic eye and thus improving the visual training effect on the user.

**[0067]** Step 104: Display the second training images on the dominant-eye display channel while displaying the first training images on the amblyopic-eye display channel to enable visual training of the user, and acquire visual training duration of the user.

**[0068]** In this embodiment, this step mainly includes: Replace the first training images played on the dominant-eye display channel with the second training images after the Gaussian blur in time, to display the second training images on the dominant-eye display channel while displaying the preset first training images on the amblyopic-eye display channel, thereby performing visual training on both eyes of the user; and acquire the visual training duration of the user.

**[0069]** In this embodiment, displaying a Gaussian-blurred image for the dominant eye while displaying a clear original image for the amblyopic eye enables the user to unconsciously increase the frequency of using the amblyopic eye when both eyes of the user simultaneously view different images, to implement visual training of the amblyopic eye and improve the visual training effect.

**[0070]** Step 105: When the visual training duration reaches a preset time threshold, stop displaying the first training images to complete the visual training of the user.

**[0071]** In this embodiment, this step mainly includes: When the visual training duration of the user exceeds the preset time threshold, stop displaying the first training images to complete the visual training of the user.

**[0072]** In the present disclosure, each visual training of the user is completed by acquiring the visual training duration of the user, to rest both eyes of the user and preserve the visual training effect.

**[0073]** This embodiment further provides a visual training system based on dichoptic viewing. For a specific structural composition of the system, refer to FIG. 2. The system mainly includes an image display module 201, an eye tracking module 202, an image processing module 203, a visual training module 204, and a training ending module 205.

**[0074]** The image display module 201 is configured to determine a dominant eye and an amblyopic eye of a user based on obtained binocular visual-acuity information of the user and

respectively create image display channels for the dominant eye and the amblyopic eye of the user through a preset dichoptic viewing technology. The image display channels include a dominant-eye display channel and an amblyopic-eye display channel.

**[0075]** The eye tracking module 202 is configured to simultaneously display a plurality of preset first training images on the dominant-eye display channel and the amblyopic-eye display channel; and when displaying each of the first training images on the dominant-eye display channel, obtain, through a preset eye tracking technology, gaze point coordinates of the dominant eye gazing at the first training image.

**[0076]** The image processing module 203 is configured to perform, through a preset Gaussian blur function based on the gaze point coordinates and the binocular visual-acuity information, a Gaussian blur on each of the first training images displayed on the dominant-eye display channel, to obtain a plurality of second training images after the Gaussian blur.

**[0077]** The visual training module 204 is configured to display the second training images on the dominant-eye display channel while displaying the first training images on the amblyopic-eye display channel to enable visual training of the user, and acquire visual training duration of the user.

**[0078]** The training ending module 205 is configured to: when the visual training duration reaches a preset time threshold, stop displaying the first training images to complete the visual training of the user.

**[0079]** In this embodiment, the image display module 201 includes an information obtaining unit and a channel display unit.

**[0080]** The information obtaining unit is configured to obtain left-eye corrected visual acuity and right-eye corrected visual acuity of the user, and determine the dominant eye and the amblyopic eye of the user by comparing the left-eye corrected visual acuity and the right-eye corrected visual acuity. The binocular visual-acuity information includes the left-eye corrected visual acuity and the right-eye corrected visual acuity.

**[0081]** The channel display unit is configured to create a first image display channel and a second image display channel based on the preset dichoptic viewing technology, such that the amblyopic eye and the dominant eye of the user respectively gaze at, through the first image display channel and the second image display channel, a training image used for visual training.

**[0082]** In this embodiment, the eye tracking module 202 includes an image display unit and an eye tracking unit.

**[0083]** The image display unit is configured to read a preset training video file, and perform image parsing on the training video file to obtain the plurality of first training images

corresponding to the training video file; and copy the plurality of first training images to the dominant-eye display channel and the amblyopic-eye display channel such that the plurality of first training images are displayed on the dominant-eye display channel and the amblyopic-eye display channel.

**[0084]** The eye tracking unit is configured to capture, based on a preset eye-tracking sensor, an eye-tracking line of sight of the dominant eye of the user gazing at the first training image; and calculate coordinates of an intersection point of the eye-tracking line of sight and the first training image through a coordinate calculation function preset in the eye-tracking sensor, and obtain the gaze point coordinates at which the eye-tracking line of sight of the dominant eye of the user falls on the first training image.

**[0085]** In this embodiment, the image processing module 203 includes a parameter determining unit, an area calculation unit, and a Gaussian blur unit.

**[0086]** The parameter determining unit is configured to determine a size of a convolution kernel, standard deviations in 2D directions, and a blurred area radius centered on a gaze point in the Gaussian blur function based on corrected visual acuity of the amblyopic eye.

**[0087]** The area calculation unit is configured to obtain, with the gaze point coordinates as a center based on the blurred area radius centered on the gaze point, a blurred area of each of the first training images displayed on the dominant-eye display channel.

**[0088]** The Gaussian blur unit is configured to perform the Gaussian blur on the blurred area of each of the first training images through the Gaussian blur function based on the size of the convolution kernel and the standard deviations in the 2D directions to obtain the second training images after the Gaussian blur.

**[0089]** In addition to the foregoing method and system, this embodiment of the present disclosure further provides a computer-readable storage medium, storing a computer program. The program, when executed by a processor, implements the visual training method based on dichoptic viewing according to this embodiment of the present disclosure.

**[0090]** In the visual training method and system based on dichoptic viewing provided by the present disclosure, the binocular visual-acuity information of the user is obtained to determine the amblyopic eye and the dominant eye of the user for accurate training based on an actual binocular visual-acuity condition of the user. Then, the image display channels are respectively created for the dominant eye and the amblyopic eye of the user through the preset dichoptic viewing technology, to enable simultaneous visual training of left and right eyes of the user. In this way, both eyes simultaneously work, to effectively reduce inhibition between both eyes and improve a visual training effect. After the image display channels are created, the preset

first training image is played on the dominant-eye display channel, and the gaze point coordinates of the dominant eye gazing at the first image are obtained through the preset eye tracking technology. The Gaussian-blurred area on the dominant-eye display channel is determined through the preset Gaussian blur function based on the gaze point coordinates and the binocular visual-acuity information. When the preset training image is simultaneously played on the dominant-eye display channel and the amblyopic-eye display channel, the training image on the dominant-eye display channel is blurred based on the blurred area and the Gaussian blur function, to effectively reduce inhibition of the dominant eye on the amblyopic eye. In this way, the amblyopic eye of the user receives a normal and sharp image during visual training, to increase a frequency of using the amblyopic eye, train coordination and balance of binocular visual functions, and improve the visual training effect.

**[0091]** Embodiment 2

**[0092]** This embodiment of the present disclosure provides another visual training method based on dichoptic viewing. For a specific implementation process of the method, refer to FIG. 3. The method mainly includes steps 301 to 303. The steps mainly include:

**[0093]** Step 301: Obtain binocular visual-acuity information of a user to determine an amblyopic eye and a dominant eye, construct a dominant-eye display channel and an amblyopic-eye display channel of the user through a preset dichoptic viewing technology, and simultaneously play preset first training images on the dominant-eye display channel and the amblyopic-eye display channel.

**[0094]** In this embodiment, this step mainly includes: Determine the dominant eye and the amblyopic eye of the user based on the obtained binocular visual-acuity information of the user and respectively create the image display channels for the dominant eye and the amblyopic eye of the user through the preset dichoptic viewing technology; read a preset training video file, and perform image parsing on the training video file to obtain a plurality of first training images corresponding to the training video file; and copy the plurality of first training images to the dominant-eye display channel and the amblyopic-eye display channel such that the plurality of first training images are displayed on the dominant-eye display channel and the amblyopic-eye display channel.

**[0095]** In this embodiment, this step is specifically as follows: Basic information of binocular visual acuity of the user is obtained, including corrected visual acuity of left and right eyes, gender, and age of the user. In this embodiment, the corrected visual acuity of the right eye of the user is set to 0.6, and the corrected visual acuity of the left eye of the user is set to 0.3. It can be determined through the corrected visual acuity that the right eye of the user is the

dominant eye and the left eye of the user is the amblyopic eye. Further, if both eyes have same visual acuity, no processing is performed. In this embodiment, before visual training is conducted on the user, the user is seated 50 cm directly in front of a display. Then, the image display channels are respectively created for the left and right eyes of the user through the preset dichoptic viewing technology, such that the left and right eyes of the user respectively view, through the image display channels, a training image used for visual training.

**[0096]** In this embodiment, the dichoptic viewing technology includes a series of technical means capable of implementing dichoptic viewing, such as an autostereoscopic 3D device, a polarized 3D display, or anaglyph glasses. In this embodiment, when the autostereoscopic 3D device is used, two independent display channels are created: a right-eye display channel named `right_channel` and a left-eye display channel named `left_channel`, to independently adjust content for each eye. `left_channel = np.zeros(frame.shape, dtype=np.uint8)`. `right_channel = np.zeros(frame.shape, dtype=np.uint8)`. Alternatively, the anaglyph glasses may be used to implement dichoptic viewing. In this embodiment, the anaglyph glasses may be red-blue glasses, which have a blue lens for the left eye and a red lens for the right eye. The left and right eyes of the user view the training image through different lenses.

**[0097]** After the left-eye and right-eye display channels are created, a video file is opened: `cap = cv2.VideoCapture('video.mp4')`. `cap` is a `VideoCapture` object, which can be used to read the video file. Each frame of image can be processed in real time in a while loop. A video frame is read: `ret, frame = cap.read()`. Each video frame is a numpy array such that a variable "frame" can be directly used to represent the image. Then, the image to be displayed is copied to the two display channels. The image is copied to the left-eye display channel: `left_channel[:] = frame`. The image is copied to the right-eye display channel: `right_channel[:] = frame`. Further, when the anaglyph glasses are used for dichoptic viewing, an original training image is split into three channels (RGB) through a split function in OpenCV, and values of the channels are manipulated such that the right eye perceives only the R channel and the left eye perceives only the G and B channels. Finally, processed channels are merged into one image through a merge function. Before the left-eye and right-eye channels are merged into a final image, a parallax effect may be adjusted by performing appropriate offset processing on two processed images. A `warpAffine` function in OpenCV may be used to implement image translation or another operation. An offset may be adjusted based on an actual requirement. With the processed left-eye and right-eye channels as input of the merge function, an output image is designated as a final composite image for display.

**[0098]** Step 302: Obtain, based on a preset eye tracking technology, gaze point coordinates of

the dominant eye gazing at the first training image, and perform a Gaussian blur on the first training image on the dominant-eye display channel through a preset Gaussian blur function based on the gaze point coordinates such that a second training image after the Gaussian blur is played on the dominant-eye display channel.

**[0099]** In this embodiment, this step mainly includes: Obtain the gaze point coordinates of the dominant eye of the user on the first training image based on a preset eye-tracking sensor, and perform the Gaussian blur on the first training image on the dominant-eye display channel through the preset Gaussian blur function based on the gaze point coordinates to obtain the second training image after the Gaussian blur.

**[0100]** In this embodiment, this step is specifically as follows: For example, in this embodiment, the preset eye-tracking sensor is used to capture a line of sight. Alternatively, a technology for obtaining an eye's line of sight, such as a line-of-sight capture function, may be used for eye tracking. In this embodiment, eye tracking is performed based on a Tobii eye-tracking sensor. In a Tobii SDK, a connection to the eye-tracking sensor is created by `tracker = tobii_research.find_all_eyetrackers()[0]; tracker.connect()`. Then, gaze point coordinates of the right eye at a current moment are obtained by `gaze_data = tracker.get_gaze_data(); right_gaze_point = gaze_data["right_gaze_point_on_display_area"]`. The obtained gaze point coordinates of the right eye are relative to a viewport coordinate system, and can be directly used to render a graphical interface or perform an operation such as interface-related calculation.

**[0101]** In this embodiment, it is known that the right-eye display channel is the dominant-eye display channel. The image on the right-eye display channel needs to be processed. With the gaze point coordinates `right_gaze_point` of the right eye as a center, an area to be blurred is calculated and controlled in real time and is Gaussian-blurred. In this embodiment, the Gaussian blur may be performed through a `GaussianBlur` function in OpenCV. Meanings of parameters in the Gaussian blur function `GaussianBlur()` are as follows:

**[0102]** `cv2.GaussianBlur(src, ksize, sigmaX[, dst[, sigmaY[, borderType]]])` → `dst`

**[0103]** `src` represents an original image to be Gaussian-blurred. `ksize` represents a size of a convolution kernel, which is expressed as (width, height) and must be a positive odd number. If only one positive integer `ksize` is given, a kernel defaults to a size of (`ksize`, `ksize`). `sigmaX` represents a standard deviation in an X direction. Its larger value indicates a smaller value in a convolution kernel, less image details, and a larger blur degree. `dst` represents a target image. It is an output parameter of the function and defaults to `None`. `sigmaY` represents a standard deviation in a Y direction and defaults to a same value as `sigmaX` if unspecified. `borderType`

represents a border mode used to extrapolate pixels outside the image, and defaults to `cv2.BORDER_DEFAULT`.

**[0104]** A smaller value of `ksize` indicates a smaller blur degree and more image details. A larger value of `ksize` indicates a larger blur degree and less image details. An excessively large value of `ksize` increases a calculation amount and may distort the image. The `sigmaX` and `sigmaY` parameters respectively control standard deviations of a Gaussian kernel function in the X and Y directions. Their larger values indicate smaller values in the convolution kernel, less image details, and an intuitively larger blur degree. If `sigmaX` and `sigmaY` have different values, a non-circular kernel is generated. `borderType` represents a border mode for extrapolating the pixels outside the image. A default value `BORDER_DEFAULT` is usually used. If a complex zero-padding method is used for an image order, blur performance and image quality may be affected. This needs to be selected and adjusted based on an actual application scenario.

**[0105]** In this embodiment, different convolution kernel sizes, standard deviations, and gaze point blurred area radii of dominant eyes are set based on different amblyopia degrees of amblyopic eyes to implement different Gaussian blur degrees. A larger amblyopia degree requires a larger blur degree. In addition, an interface is provided for a trainer to adjust parameters, including a blur degree, a blur radius, and the like, based on an actual condition of the user or feedback from the user. A system adjusts the parameters based on settings of the trainer. Parameters exemplified in the present disclosure are merely examples for convenience of description of the technical solutions.

**[0106]** In this embodiment, amblyopia may be set to be classified into severe, moderate, and mild amblyopia: Visual acuity below 0.2 belongs to severe amblyopia. Visual acuity of 0.2 to 0.5 belongs to moderate amblyopia. Visual acuity of 0.6 to 0.8 belongs to mild amblyopia.

**[0107]** For mild amblyopia, a blur effect is light, central details are mainly removed, and an obvious outline remains visible at a periphery. A convolution kernel is as follows: `ksize(3, 3)`, `sigma = 1`, and `blur_rect_size(100, 100)`.

**[0108]** For moderate amblyopia, a central part is obviously blurred, and a periphery is also blurred, but a whole is still identifiable. A convolution kernel is as follows: `ksize(5, 5)`, `sigma = 1.5`, and `blur_rect_size(150, 150)`.

**[0109]** For severe amblyopia, the whole image is blurred, and only an approximate color and outline are distinguished. A convolution kernel is as follows: `ksize(7, 7)`, `sigma = 2`, and `blur_rect_size(200, 200)`. A rectangular frame for the blurred area is calculated based on the gaze point coordinates.

**[0110]** `blur_rect = ((right_gaze_point.x - blur_rect_size[0] // 2, right_gaze_point.y - blur_rect_size[1] // 2), (right_gaze_point.x + blur_rect_size[0] // 2, right_gaze_point.y + blur_rect_size[1] // 2))`

**[0111]** An image `right_img` on the right-eye display channel is read, and a Gaussian blur is performed on the blurred area.

**[0112]** `right_img[blur_rect[0][1]:blur_rect[1][1],blur_rect[0][0]:blur_rect[1][0]]=cv2.GaussianBlur(right_img[blur_rect[0][1]:blur_rect[1][1],blur_rect[0][0]:blur_rect[1][0]],ksize, sigma)`

**[0113]** After the Gaussian blur is completed, the right-eye display channel is updated to a processed image. On the dominant-eye display channel, only a gaze point area is blurred while the rest of the image remains clear. On the amblyopic-eye display channel, there is a normal and sharp image.

**[0114]** Step 303: Display the second training image on the dominant-eye display channel while displaying the first training image on the amblyopic-eye display channel to enable visual training of the user, and end the visual training of the user when visual training duration of the user is greater than a preset time threshold.

**[0115]** In this embodiment, this step is specifically as follows: The second training image after the blur is played for the dominant eye of the user while the original training image corresponding to the second training image without a Gaussian blur is played for the amblyopic eye of the user. A process in which the user watches a video is a visual training process, with excellent compliance. A watching time of 15 to 30 minutes may be set for each training. The user unconsciously improves visual acuity and restores a visual function while watching a favorite video.

**[0116]** In addition, in this embodiment, during training, eye movement data of the user, including eye movement trajectories and the like, may be recorded for analyzing compliance of the user. The trainer needs to regularly check improvements in visual acuity, continue to personalize blur parameters based on a visual acuity improvement degree, and dynamically update and adjust the parameters to adapt to a visual status for improved visual acuity.

**[0117]** In the visual training method based on dichoptic viewing provided by the present disclosure, visual content is divided into two independent channels based on an eye-tracking sensor and an innovative image processing algorithm running in real time, enabling separate manipulation of content for each eye. The system blurs a visual center of the dominant eye based on amblyopia severity while keeping the rest of the image clear. The blur is completed in real time based on an instantaneous gaze position of the dominant eye. The amblyopic eye receives a normal and sharp image. This effectively reduces inhibition between both eyes, to

make more use of the amblyopic eye. In this way, a frequency of using the amblyopic eye is increased, and the user unconsciously improves the visual acuity and restores the visual function while viewing a screen.

**[0118]** Compared with traditional computer-based visual training, the method provided in this embodiment does not require development of special visual training tasks. Instead, thousands of existing multimedia resources can be utilized. For example, the user may open a video or a video website and watch a movie or a cartoon that the user likes. The system processes images in real time while the user is watching the video. In this way, the user unconsciously completes visual training. This can greatly improve the compliance of the user and eliminate a need for an interaction operation of the user, such as using a mouse. The present disclosure is simpler to use and achieves better compliance than an existing technical solution.

**[0119]** The objectives, technical solutions, and beneficial effects of the present disclosure are further described in detail through the foregoing specific embodiments. It should be understood that the foregoing are merely specific embodiments of the present disclosure, but are not intended to limit the protection scope of the present disclosure. It should be particularly noted that any modifications, equivalent substitutions, improvements, and the like made by those skilled in the art within the spirit and principle of the present disclosure should be included within the protection scope of the present disclosure.

## CLAIMS:

1. A visual training method based on dichoptic viewing, comprising:

determining a dominant eye and an amblyopic eye of a user based on obtained binocular visual-acuity information of the user and respectively creating image display channels for the dominant eye and the amblyopic eye of the user through a preset dichoptic viewing technology, wherein the image display channels comprise a dominant-eye display channel and an amblyopic-eye display channel;

simultaneously displaying a plurality of preset first training images on the dominant-eye display channel and the amblyopic-eye display channel; and when displaying each of the first training images on the dominant-eye display channel, obtaining, through a preset eye tracking technology, gaze point coordinates of the dominant eye gazing at the first training image;

performing, through a preset Gaussian blur function based on the gaze point coordinates and the binocular visual-acuity information, a Gaussian blur on each of the first training images displayed on the dominant-eye display channel, to obtain a plurality of second training images after the Gaussian blur;

displaying the second training images on the dominant-eye display channel while displaying the first training images on the amblyopic-eye display channel to enable visual training of the user, and acquiring visual training duration of the user; and

when the visual training duration reaches a preset time threshold, stopping displaying the first training images to complete the visual training of the user.

2. The visual training method based on dichoptic viewing according to claim 1, wherein the determining a dominant eye and an amblyopic eye of a user based on obtained binocular visual-acuity information of the user and respectively creating image display channels for the dominant eye and the amblyopic eye of the user through a preset dichoptic viewing technology comprises:

obtaining left-eye corrected visual acuity and right-eye corrected visual acuity of the user, and determining the dominant eye and the amblyopic eye of the user by comparing the left-eye corrected visual acuity and the right-eye corrected visual acuity, wherein the binocular visual-acuity information comprises the left-eye corrected visual acuity and the right-eye corrected visual acuity; and

creating a first image display channel and a second image display channel based on the preset dichoptic viewing technology, whereby the amblyopic eye and the dominant eye of the user respectively gaze at, through the first image display channel and the second image display

channel, a training image used for visual training.

3. The visual training method based on dichoptic viewing according to claim 1, wherein the simultaneously displaying a plurality of preset first training images on the dominant-eye display channel and the amblyopic-eye display channel comprises:

reading a preset training video file, and performing image parsing on the training video file to obtain the plurality of first training images corresponding to the training video file; and

copying the plurality of first training images to the dominant-eye display channel and the amblyopic-eye display channel, whereby the plurality of first training images are displayed on the dominant-eye display channel and the amblyopic-eye display channel.

4. The visual training method based on dichoptic viewing according to claim 1, wherein the obtaining, through a preset eye tracking technology, gaze point coordinates of the dominant eye gazing at the first training image comprises:

capturing, based on a preset eye-tracking sensor, an eye-tracking line of sight of the dominant eye of the user gazing at the first training image; and

calculating coordinates of an intersection point of the eye-tracking line of sight and the first training image through a coordinate calculation function preset in the eye-tracking sensor, and obtaining the gaze point coordinates at which the eye-tracking line of sight of the dominant eye of the user falls on the first training image.

5. The visual training method based on dichoptic viewing according to claim 2, wherein the performing, through a preset Gaussian blur function based on the gaze point coordinates and the binocular visual-acuity information, a Gaussian blur on each of the first training images displayed on the dominant-eye display channel comprises:

determining a size of a convolution kernel, standard deviations in two-dimensional (2D) directions, and a blurred area radius centered on a gaze point in the Gaussian blur function, based on corrected visual acuity of the amblyopic eye;

obtaining, with the gaze point coordinates as a center based on the blurred area radius centered on the gaze point, a blurred area of each of the first training images displayed on the dominant-eye display channel; and

performing the Gaussian blur on the blurred area of each of the first training images through the Gaussian blur function based on the size of the convolution kernel and the standard deviations in the 2D directions to obtain the second training images after the Gaussian blur.

6. A visual training system based on dichoptic viewing, comprising: an image display module, an eye tracking module, an image processing module, a visual training module, and a training ending module; wherein

the image display module is configured to determine a dominant eye and an amblyopic eye of a user based on obtained binocular visual-acuity information of the user and respectively create image display channels for the dominant eye and the amblyopic eye of the user through a preset dichoptic viewing technology, wherein the image display channels comprise a dominant-eye display channel and an amblyopic-eye display channel;

the eye tracking module is configured to simultaneously display a plurality of preset first training images on the dominant-eye display channel and the amblyopic-eye display channel; and when displaying each of the first training images on the dominant-eye display channel, obtain, through a preset eye tracking technology, gaze point coordinates of the dominant eye gazing at the first training image;

the image processing module is configured to perform, through a preset Gaussian blur function based on the gaze point coordinates and the binocular visual-acuity information, a Gaussian blur on each of the first training images displayed on the dominant-eye display channel, to obtain a plurality of second training images after the Gaussian blur;

the visual training module is configured to display the second training images on the dominant-eye display channel while displaying the first training images on the amblyopic-eye display channel to enable visual training of the user, and acquire visual training duration of the user; and

the training ending module is configured to: when the visual training duration reaches a preset time threshold, stop displaying the first training images to complete the visual training of the user.

7. The visual training system based on dichoptic viewing according to claim 6, wherein the image display module comprises an information obtaining unit and a channel display unit;

the information obtaining unit is configured to obtain left-eye corrected visual acuity and right-eye corrected visual acuity of the user, and determine the dominant eye and the amblyopic eye of the user by comparing the left-eye corrected visual acuity and the right-eye corrected visual acuity, wherein the binocular visual-acuity information comprises the left-eye corrected visual acuity and the right-eye corrected visual acuity; and

the channel display unit is configured to create a first image display channel and a second

image display channel based on the preset dichoptic viewing technology, whereby the amblyopic eye and the dominant eye of the user respectively gaze at, through the first image display channel and the second image display channel, a training image used for visual training.

8. The visual training system based on dichoptic viewing according to claim 6, wherein the eye tracking module comprises an image display unit and an eye tracking unit;

the image display unit is configured to read a preset training video file, and perform image parsing on the training video file to obtain the plurality of first training images corresponding to the training video file; and copy the plurality of first training images to the dominant-eye display channel and the amblyopic-eye display channel whereby the plurality of first training images are displayed on the dominant-eye display channel and the amblyopic-eye display channel; and

the eye tracking unit is configured to capture, based on a preset eye-tracking sensor, an eye-tracking line of sight of the dominant eye of the user gazing at the first training image; and calculate coordinates of an intersection point of the eye-tracking line of sight and the first training image through a coordinate calculation function preset in the eye-tracking sensor, and obtain the gaze point coordinates at which the eye-tracking line of sight of the dominant eye of the user falls on the first training image.

9. The visual training system based on dichoptic viewing according to claim 6, wherein the image processing module comprises a parameter determining unit, an area calculation unit, and a Gaussian blur unit;

the parameter determining unit is configured to determine a size of a convolution kernel , standard deviations in two-dimensional (2D) directions, and a blurred area radius centered on a gaze point in the Gaussian blur function based on corrected visual acuity of the amblyopic eye;

the area calculation unit is configured to obtain, with the gaze point coordinates as a center based on the blurred area radius centered on the gaze point, a blurred area of each of the first training images displayed on the dominant-eye display channel; and

the Gaussian blur unit is configured to perform the Gaussian blur on the blurred area of each of the first training images through the Gaussian blur function based on the size of the convolution kernel and the standard deviations in the 2D directions to obtain the second training images after the Gaussian blur.

10. A computer-readable storage medium, storing a computer program, wherein the program, when executed by a processor, implements the visual training method based on dichoptic viewing according to any one of claims 1 to 5.